Phys 1402 2016-10-13 Lec 15

HW4a is posted - Don't Wait!

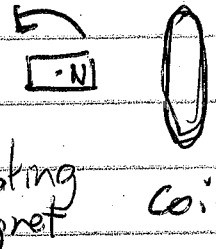
Faraday's Law - Voltage generated by a coil.

$$\mathcal{E} = -\frac{\Delta \Phi_B}{\Delta t}$$

$$\Phi_B = NBA\cos\theta$$

How can we generate voltage?

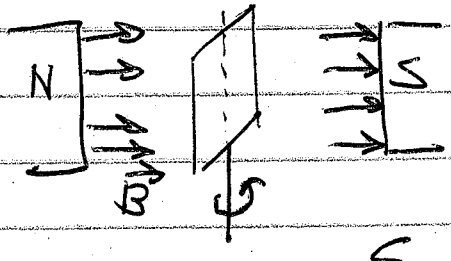
- Change A = Area. Ex: Bar on rails
- Change B = magnetic field



rotating magnet coil

$$\mathcal{E}_{max} = \frac{\Delta B}{\Delta t} NA\cos\theta$$

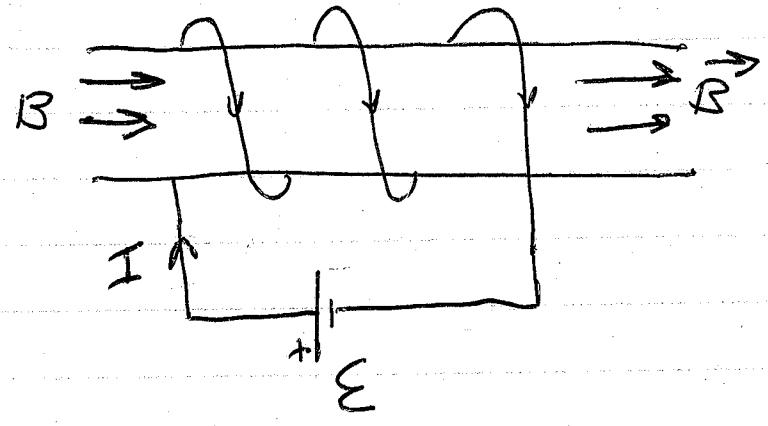
- Change θ = angle



$$\mathcal{E}_{max} = NBA\,\omega$$

$$\frac{\Delta\theta}{\Delta t}$$

Solenoid Coil



- Current causes magnetic Field

$$B = \frac{\mu_0 N I}{l} = \mu_0 n I$$

N = # loops
l = length
n = # loops / length

- "Magnetic Field is "felt" as Flux

$$\Phi_B = NBA \cancel{\cos\theta}^{1}$$

A = area = πr^2
or A = w·h

$$= N\left(\frac{\mu_0 N I}{l}\right) A$$

$$= \underbrace{\left(\frac{\mu_0 N^2 A}{l}\right)}_{\text{constant}} \cdot \underbrace{I}_{\text{variable}} = L \cdot I$$

L ← Inductance

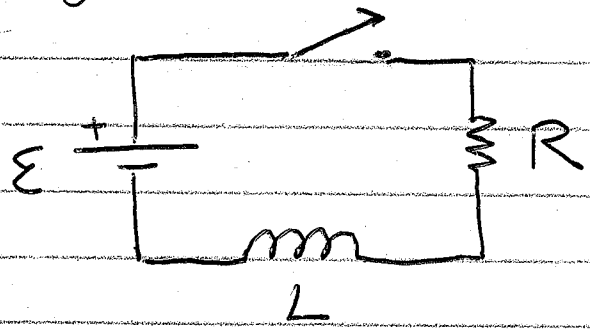
- Changing Flux generates EMF

$$\mathcal{E} = -\frac{\Delta \Phi_B}{\Delta t} = -\left(\frac{\mu_0 N^2 A}{l}\right)\frac{\Delta I}{\Delta t} = -L\frac{\Delta I}{\Delta t}$$

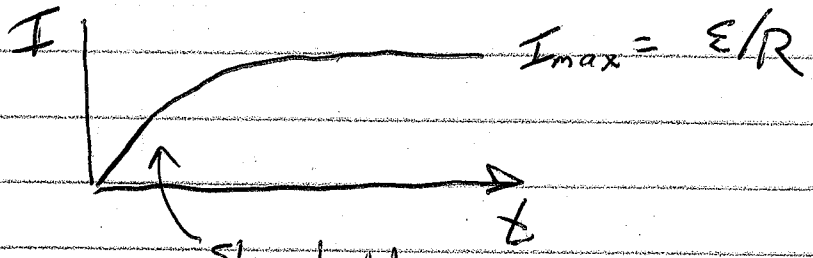
What is inductance (L)?

- Tendancy to fight change in current.

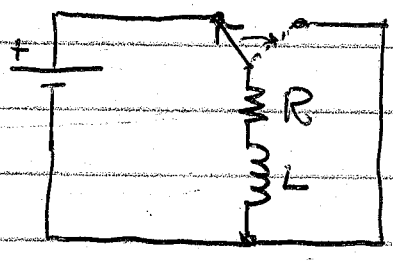
- Current starts @ zero, inductor fights increase in current.



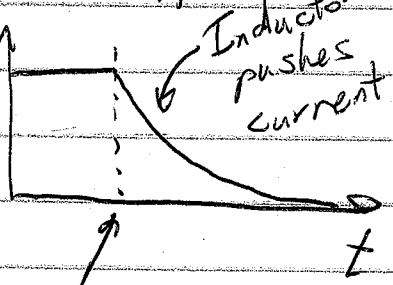
Close switch & current rises slowly.



- Current starts high - try to cut off



"Inductive Kick"



④

Inductance (L) is measured in henries (H).

- Links Flux & Current

$$\Phi_B = L I$$

- Links EMF & Change of Current

$$\mathcal{E} = -L \frac{dI}{dt}$$

Typical Calculation

$$B = \boxed{\frac{\mu_0 N I}{l}} \qquad \Phi_B = \boxed{NBA} \qquad L = \frac{\Phi_B}{I}$$

Solenoid: $L = \frac{\mu_0 N^2 A}{l}$

Later: Current will oscillate

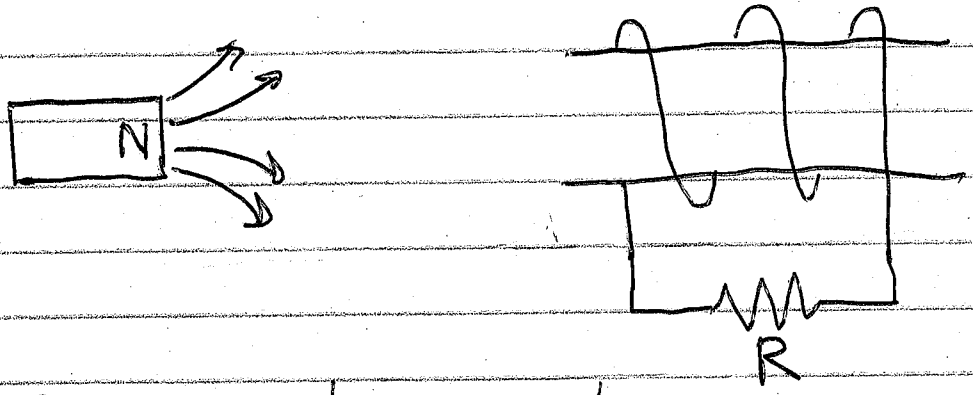
- Fast oscillations are fought by inductors. Inductor impedes high-frequencies.
- Slow oscillations are fought less
- Zero oscillations are DC and pass without impedance.

(5)

Lenz's Law - Direction of EMF

- Change in Φ_B → EMF
- EMF → maybe → Induced Current
- Induced Current → Fights Change → Change in Φ_B

Solenoid Coil



① Bring magnet near coil.

② $\vec{B}$ points right and increasing.

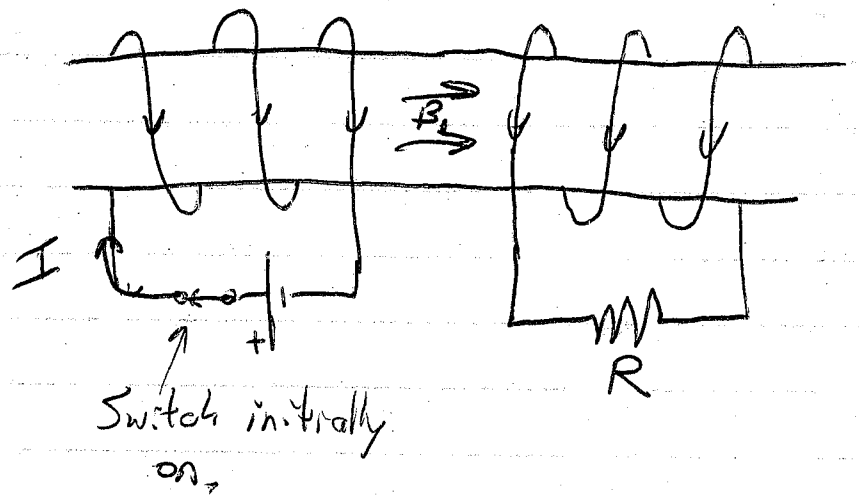
③ To Fight the increase, coil makes induced B:

$\vec{B}_{ind}$ = left (to fight increase)

④ To generate $\vec{B}$ = left, current flows up front, down back in coil.

⑤ In the resistor, the current flows to the right.

⑥



① Turn switch off. What happens in R?

② B_1 points <u>to right</u> and is <u>decreasing</u>.

③ To fight the decrease, B_2 = <u>rightward</u>.

④ For B_2 = right, I_2 = <u>down the front</u>

⑤ In the resistor, I_2 = <u>Rightward</u>.